

our tabulation areas. One main object is that our primary framework of areas and sub-areas should separate our species and genera (so far as possible) into those areas and sub-areas; if a boundary line is drawn between two sub-areas A and B, so that nearly all the species found on one side of it are also found on the other, then we might as well, in this tabulation, have thrown the two sub-areas A and B into one, and saved ourselves labour. This brings us round practically pretty nearly to Wallace's view again; *i.e.*, geographic framework for reference and tabulation must be as near as possible to a system of natural biologic regions, subject to the condition that the boundary lines are rapidly and accurately fixed, and are easily remembered. It is impracticable to effect large tabulations of tens of thousands of specimens if it is necessary continually to refer to some special large-scale map.

The present paper is not intended to include marine regions or areas.

- V. "The Electric Organ of the Skate: Observations on the Structure, Relations, Progressive Development, and Growth of the Electric Organ of the Skate." By J. C. EWART, M.D., Regius Professor of Natural History, University of Edinburgh. Communicated by Prof. J. BURDON SANDERSON, F.R.S. Received February 10, 1892.

(Abstract.)

After referring to the observations of Stark, the discoverer of the skate's electric organ, and to the work of Robin, Leydig, Babuchin, and others, the author describes the arrangement of the muscles in the tail of Selachians with a view to determining which muscles in the skate are transformed into the electric organs.

By comparing the caudal muscles of *Scyllium*, *Lamna*, *Myliobatis*, and *Raia*, it is made out that, while the middle row of muscular cones remains unaltered in the sharks and rays, it is transformed into a more or less perfect electric organ in the skates, the various members of the genus *Raia*. It is pointed out that, while the middle row of muscular cones is transformed in *Raia* into electric cones, the two adjacent rows of cones as in the rays and certain sharks diminish in size, and in some cases disappear about the middle of the tail.

In considering the structure of the organ, it is stated that, when the various modifications are taken into consideration, it may be described as consisting of a series of electric cones made up of more or less completely metamorphosed muscular fibres. Twenty-eight distinct cones were counted in the organ of *R. batis*. The first, which in a half grown fish measured 5 cm. in length, was all but

completely invested by the last unaltered muscular cone. From the first to the tenth the cones slightly increased in length; but from the eleventh they diminished in length, the twenty-sixth measuring only 0.75 cm. Beyond the twenty-eighth there were from six to eight incomplete cones.

In transverse sections the anterior third of the organ was seen to present an oval or rounded form, while the middle and posterior thirds were less regular, owing to the organ coming into contact with the vertebral column, and being grooved by the dorsal and ventral muscles.

The cones are described as consisting of numerous loculi or chambers, each having an electric disc suspended by nerve fibres from its anterior wall, and occupied in front and behind the disc with gelatinous tissue.

It is estimated that each organ in *R. batis* is made up of about 10,000 electric elements, *i.e.*, about 20,000 in the two organs. *Torpedo marmorata* has about 500,000, and *T. gigantea* about 1,000,000, elements in the two batteries, all considerably larger than those of the skate.

The layers of the electric discs, the electric, striated, and alveolar, are described in detail; and the various views as to the termination of the nerve fibrils in the disc are referred to.

In the chapter on the progressive growth of the organ a table is given to show that in *R. batis* the organ, after a time, grows at a greater rate than the tail in which it is lodged, *e.g.*, in fish 60 cm. in length the tail measures about 28 cm., and the electric organ 22.5 cm.; well-formed discs having an area of 0.8 to 1 sq. mm. In fish 225 cm. in length the tail measures 85 cm., the organ 70 cm., and the discs have an area of about 2.08 sq. mm. In fish from 25.5 to 30.5 cm. in length the organ is from 12.78 to 14.0 cm., and weighs 0.5 to 0.6 gram; in fish from 83.5 to 91.25 cm. the organ is from 30.50 to 34.25 cm., and weighs from 6.0 to 8.0 grams; in fish 157 cm., the organ measures 48.25 cm., and weighs 25.00 grams; while in 225 cm. fish the organ, which measured 70.00 cm., weighed 156.00 grams. These facts, especially the great size and weight of the organ in large skate (about 7 feet in length), do not seem to point to the skate's organ being in process of degeneration; more especially as the increase in size is not accompanied by any histological changes of a retrogressive nature, the largest organ examined being apparently as perfect as that of *Torpedo* and *Gymnotus*.

In discussing the organ from a physiological point of view, reference is made to the investigations of Sanderson and Gotch, and it is pointed out that, when the electric plate is taken as the unit, the value per square millimetre of the single plate of the skate is in all probability equal to, if not greater than, that of the torpedo.

The structures of the organs of the skate and torpedo are compared at length, and it is shown that in the case of the torpedo all the non-essential structures are absent, while the all-essential part, the electric layer or plate, closely resembles the corresponding layer or plate in the skate, the electric layer of *R. circularis* being especially like that of the torpedo.

In considering the modifications of the electric organ in the skate genus, it is shown that in all the British species, with the exception of *R. radiata*, *R. circularis*, and *R. fullonica*, the elements are in the form of discs. In the three exceptions the elements are more or less cup-shaped. In *R. radiata*, as described in a former paper, they are in the form of thick-walled shallow cups. The electric plate, apparently a greatly enlarged motor plate, lines the cup, which throughout resembles an ordinary striated muscle. In *R. circularis*, a more specialised member of the group, the electric elements are larger and better developed. The cups are deep and well moulded, and the electric layer is even more complex than in *R. batis*; at least, it more closely resembles the electric layer of the torpedo. Further, the cups are invested by a thick nucleated cortex, from which a number of delicate short processes project—the first appearance of the long prongs found in *R. batis*. In *R. fullonica* the electric elements stand nearly midway between the only partially transformed muscular fibres of *R. radiata* and the complex discs of *R. batis*. The cups in *R. fullonica* are less deep than in *R. circularis*; and while the electric and striated layers appear to be all but identical in the two species, the cortex is decidedly more like that of *R. batis*. The short simple processes of *R. circularis* are represented in *R. fullonica* by processes, often complex, which, by projecting freely from the outer surface of the cup, give it an irregular villous appearance, and at once suggest the processes or prongs which are so characteristic of the alveolar layer of *R. batis*.

After giving a summary of his observations on the electric organ of the skate, the author concludes by pointing out that it is not yet possible to indicate by what method the electric organs of fishes have been produced.

*Presents, February 25, 1892.*

Transactions.

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